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# Lubrication

A Technical Publication Devoted to  
the Selection and Use of Lubricants

THIS ISSUE

Lubrication Recommen-  
dations and Their  
Development

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**THE TEXAS COMPANY**  
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# THE *Right* LUBRICANT



THE development of a lubrication recommendation for industrial or power plant machinery can be likened to the study which is given by a Doctor before diagnosing—and writing a prescription. Just as human ailments may vary to require specific treatment, so may machinery operations differ to a sufficient extent to require specific grades of lubricants.

In the attainment of effective lubrication there are certain controlling factors which should be carefully studied before a lubricant is recommended for any installation; these include operating conditions and the design and construction of the equipment involved. Since these factors may vary it is impracticable to state that for any particular type of equipment a lubricant of certain definite characteristics should always be used. Consideration should first be given to the speed of operation, the prevailing operating temperatures, the extent to which pressure may be developed between the moving parts, the means provided for lubrication and the degree to which the wearing elements may be exposed, subjecting the lubricants to contamination.

Texaco Engineers are trained to study these problems and *every factor* is taken into consideration before a final recommendation is made.



**THE TEXAS COMPANY**

*Texaco Petroleum Products*

# LUBRICATION

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## Lubrication Recommendations and Their Development

**I**N the practice of lubrication engineering the decision as to the proper grade of lubricant to use on any piece of machinery will be one of the most important details which may devolve upon the Lubricating Engineer. In fact, it will often be the ultimate factor between success and failure in the development of efficient operation.

The determination of a lubrication recommendation must, therefore, be approached with caution, and only decided upon after careful study of the existing operating and constructional conditions, which may affect the lubricating ability of the oils or greases in question.

In view of the fact, however, that certain types of machinery may function with comparative satisfaction on a wide variety of lubricants the thought may occur to the layman that perhaps this matter of definite lubrication recommendations is over-stressed. But one must realize the extent to which power consumption may be affected. It is perfectly true

that virtually any good grade of oil or grease will develop lubrication, but how effectively this will result in the maximum reduction of friction will depend upon the ability of the resultant lubricating film to withstand the operating pressures, temperatures and the possibility of contamination.

So extensively has all this been studied that we feel convinced in stating that in the majority of cases for any particular type of service there will be some one specific product which will insure the most satisfactory service, by virtue of some inherent characteristic.

It is the duty of the Lubricating Engineer to study the details of design, the operating conditions, and the means of lubrication available in order to decide upon this so-called ideal lubricant. In fact, it may be safely said that the development of the average lubrication recommendation will depend upon these three primary factors as mentioned above.

## Design

In order to be able to study the relationship of lubrication to design it is essential that the lubricating engineer have an intimate knowledge of the intended function of the machinery with which he is dealing, and the manner in which this function has been anticipated by the designing engineer in making the plans.

The intricacy of design will be determined by the function of the machine; the hydraulic

turbine, for example, although comparatively massive, must be designed in a most careful manner in order that its intended alignment will be maintained and the thrust pressure developed during operation prevented from becoming so abnormal as to cause damage to the thrust bearings.

On the other hand, a steam pump is normally a very simple mechanism. In consequence, it is not essential to devote any ex-

tensive amount of care to its construction, other than to insure that the moving parts fit properly, for it must be realized that the steam pump is normally operated under conditions which will not be conducive to most effective lubrication. Therefore, the bearings of a reciprocating boiler feed pump, for instance, should not be expected to show as long a life as those of a hydraulic or steam turbine.

## Function of the Designing Engineer

In the majority of cases those factors which enter into the operation of any piece of machinery are taken into consideration by the designing engineer. If it is impossible to prevent a machine from coming in contact with abrasive foreign matter he may be justified in not giving it the same care as he would to a device which can be installed apart from dust or dirt, and the detrimental effects of water, or wide temperature variations.

It is perfectly practicable, however, to design certain types of machinery, notably the electric motor and some varieties of machine tools, in such a dust tight manner as to absolutely insure maintenance of quite as effective lubrication as can be secured where these conditions do not exist.

This has been materially aided by the development of the anti-friction bearing and the success achieved by the builders of such bear-

or other moving parts is such that the service will be comparatively rough, if it is impracticable to prevent drip or waste, a cheaper grade of lubricant can normally be recommended than where such conditions do not exist.

To be true, a cheaper grade of lubricant may not possess the same lubricating ability as a more highly refined product; on the other hand, the use of the latter under such conditions would not be economical nor an assurance of any better lubrication, due to the fact that it might become unduly contaminated, with consequent reduction in its original lubricating ability. Furthermore, were it to drip or be wasted prematurely the first cost would not be justified.

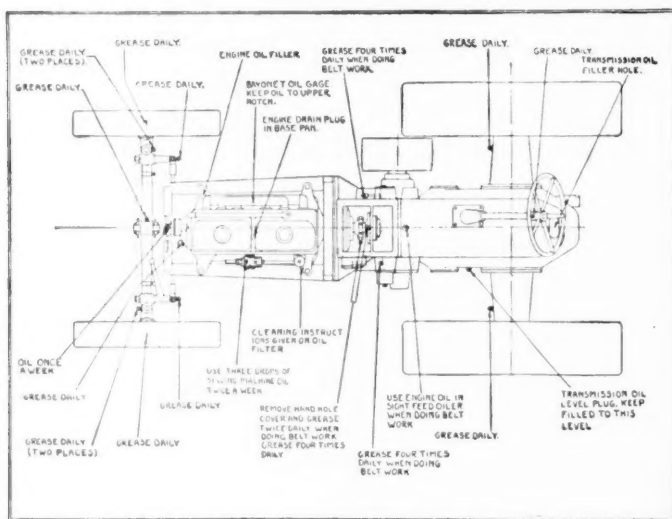
It is erroneous to feel, however, that where original design may be such as to lead to waste of lubricants, endeavor should not be made to overcome this, if it can be accomplished without abnormal expense. This will be especially true under conditions which may cause contamination of lubricants during operation.

There are many ways by which waste can be prevented. They will depend to a large extent on the design of the equipment, the product being handled, the duty involved and the location. In the steel mill, for example, especially on certain older types of equipment, gears and bearings are frequently but inadequately protected from the scale, dust, dirt and sometimes water which may come in contact with such moving parts.

It has been proven, however, that gears can be enclosed in sheet metal housings, and bearing guards installed which will materially reduce the extent to which lubricants may be contaminated. By this prevention of contamination the durability and life of such products can be extended.

It is, therefore, the function of the lubricating engineer to study design from this point of view. He may, however, not always be able to prevail on his accounts to spend the money for such means of protection. It is then his duty to decide upon grades of lubricants commensurate with the operating conditions as they may prevail.

A theoretical lubrication recommendation for any specific type of machine, however, is as of an ideal, for it is based upon design and the assumption that the user has realized the importance of lubrication and the necessity for protecting the machine as much as possible.



Courtesy of Minneapolis Steel and Machinery Co.

ings in construction of dust guards and means of lubricant retention.

Design is, therefore, a criterion as to the degree of refinement essential in a lubricant. Wherever the design of bearings, gears, chains



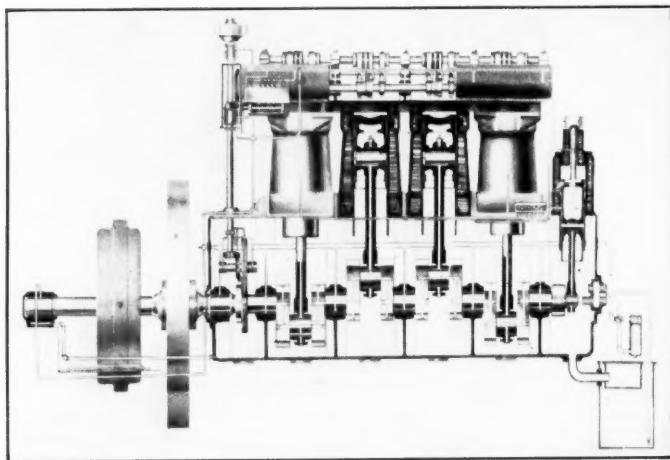


amount of internal friction developed within the lubricant itself.

Wherever grease is to be used as a lubricant for high speed conditions it is well to remember that such a lubricant is more particularly adaptable to anti-friction bearing construction. It has been proven that if the bearing is properly designed to retain the lubricant, and a product chosen with a high degree of lubricating ability, it will insure lubrication for an extensive period of operation, with the necessity for only infrequent renewal.

It is important to remember that the anti-friction bearing should not be completely filled with lubricant, for this may not only lead to channelling of the product but also to increased power consumption, due to the drag which may be imposed upon the rolling elements.

When gears, chains or other motions are involved, however, speed must be studied from the viewpoint of the extent to which centrifugal force will be developed and the lubricant thrown from the moving parts. Here, therefore, there is more relationship between speed and the adhesive characteristics of the lubricants. This will be especially true on exposed gears or chains. In an oil-tight gear or chain housing a comparatively fluid oil can be used, especially if it is automatically delivered to the parts and not merely carried to these by virtue of the dipping of the gear teeth or chain sprockets in the bath of lubricant.



*Courtesy of Worthington Pump and Machinery Co.*

Fig. 3—Lubricating oil system of a Worthington 4-cycle air injection Diesel engine. Note that the gears and bearings are pressure lubricated by a geared pump. This is driven from the main shaft. The flow of oil can be readily followed.

Where gears and chains are not tightly housed, however, thought must be given to the adhesive characteristics as well as the viscosity of the lubricant. It is for this reason that straight mineral petroleum products are

more adaptable to such installations than compounds such as greases.

There are certain of these latter, of course, which have comparatively high adhesive tendencies. On the other hand, they will be more expensive and not as durable for the service involved as the straight mineral residual gear lubricants. Here again it is within the province of the lubricating engineer to study the installation and make his recommendation accordingly, explaining, of course, to the operator his reasons for determining how heavy a product should be used.

## PRESSURE

In considering pressure alone from the viewpoint of the degree to which it may impair lubrication, the important point to remember is that if the viscosity or consistency of the lubricant is not sufficient to withstand any squeezing out action which may be developed due to the construction of the moving parts, considerable damage because of lack of proper lubrication will probably follow. As a result, pressure is one of the salient factors which must be considered in the study of any lubricating problem and the preparation of a lubrication recommendation.

It is evident that under average conditions the greater the existing or operating pressure between any two wearing elements, the heavier or more viscous must be the lubricating film in order to prevent metal-to-metal contact. This holds true whether bearings, gear teeth or chain link connections are involved. The logical effect of pressure will be a tendency toward squeezing out of the lubricating film from between the wearing surfaces. In a bearing the essential solution to this problem will be proper grooving and adequate bearing area.

On the other hand, with certain types of wearing elements the danger of impaired lubrication due to pressure can be partially prevented by enclosed construction, and the operating of the parts in a bath or flood of lubricant. Relative to the development of such pressures, however, it must be remembered that the period of maximum intensity is relatively brief.

In other cases, pressure can be met with pressure, the lubricant being maintained within the clearance spaces under the prevailing pressure of some form of pumping device. This is, however, impracticable on open-ended bearings.

## LUBRICATION

### Conditions Involved

But, irrespective of the means of application, a certain degree of adhesiveness and sufficient viscosity must be prevailing characteristics of the lubricant itself. To make any other than generalized statements as to the viscosity range would be unwise. Too much will depend upon conditions of construction, operation and means of application. It will be far better to study these latter conditions in order that the severity of the duty may be realized. With such knowledge as a basis, and an understanding of what is actually involved when we speak of viscosity, etc., the problem of subsequently selecting either oils or greases to function effectively should be materially simplified.

It is practicable to use either oil or grease for the lubrication of many of the wearing elements. The ultimate factor will involve the type of lubricating equipment provided, and the operating conditions such as speed and bearing pressures, and details of construction such as manner of grooving.

By virtue of the size, duty, and bulky nature of the moving parts of the average machine involving high pressures, it has been deemed advisable in many cases to provide for some form of positive, automatic lubrication. Greater convenience should thereby result, with frequently marked savings in labor due to reduction in the amount of attention necessary.

Typical examples will be rolling equipment in the steel mill, the metal press in the automotive plant, the cement kiln and the news or textile press, or the milling machine.

In virtually any piece of machinery where pressure may prevail it is important to remember that it is the "operating pressure" which must be considered. When the rolling mill or metal press, for example, is idling, the pressure which may exist between the teeth of its gear trains, or upon the bearings of certain of its shafting may not be abnormal. When idling there should, therefore, be no problem in the maintenance of lubrication on such equipment.

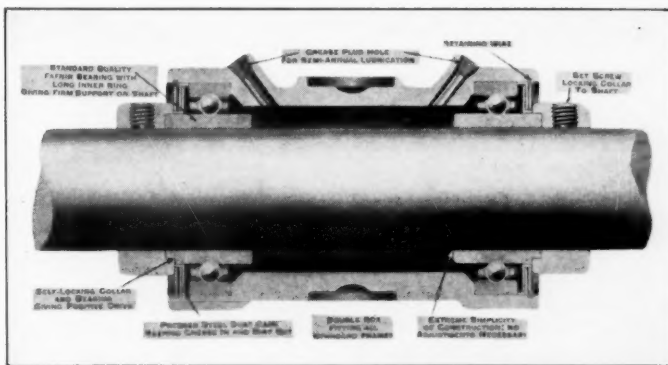
When under operation, however, the pressure exerted upon the raw materials in the formation of finished or semi-finished products will react back through practically all the moving elements of the machine. Not with the same intensity in every case, to be sure, for this will depend upon the size or relative importance of the parts involved. But, in general, such reactionary or back pressures will be considerably in excess of the idling pressures, and hence they will be a potential cause of lubricating difficulties.

### Operating Pressure the Criterion

As a result, it is the operating pressure which must be taken into account when selecting lubricants for any particular type of heavy duty machinery, or its respective wearing elements.

The purpose, of course, must be to use lubricants which will be of such body and adhesive ability as to effectively withstand being squeezed out from between gear teeth, chain link connections, or bearings and shafting. These characteristics in the lubricants must be considered from the viewpoint of maximum pressure involved.

Of course, on certain machinery this may result in abnormal internal friction within



*Courtesy of The Fafnir Bearing Company*

Fig. 4—Sectional detail of a Fafnir ball bearing. Here again a study of constructional conditions will enable more positive judgment as to the proper lubricant to use according to the operating conditions.

some lubricants when the machinery is idling, but it is far more important to prevent metal-to-metal contact under high operating pressures and thereby preclude the development of abnormal wear, than to reduce power consumption during idling. This is especially true inasmuch as such machinery to develop maximum efficiency should idle as little as possible.

### Relation of Viscosity

The effect of pressure upon the viscosity of lubricants has been studied in detail by Hersey and Shore\* and their paper on this pertinent topic as presented before the American Society of Mechanical Engineers is noteworthy for its developments. It stresses the desirability of—"knowledge of the viscosity of oils up to a moderately high pressure"—especially for metal-drawing processes and hydraulic press operation, etc.

So a consideration of viscosity as a factor in the selection of lubricants for service under high operating pressures will be of interest.

Viscosity being a measure of the relative fluidity of a lubricant is indicative of the body

\*"Viscosity of Lubricants Under Pressure" by Mayo D. Hersey and Henry Shore. Presented at the Annual Meeting of the A. S. M. E., Dec. 1927.

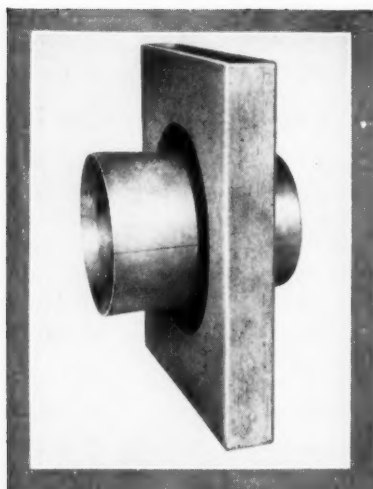


Fig. 5 — Left — In electric railway journal bearing lubrication the oil seal is a decided adjunct. Here is shown this seal in reverse position in the dust guard slot, being expanded by the conical surface of a template to slip over the conical surface of the axle.

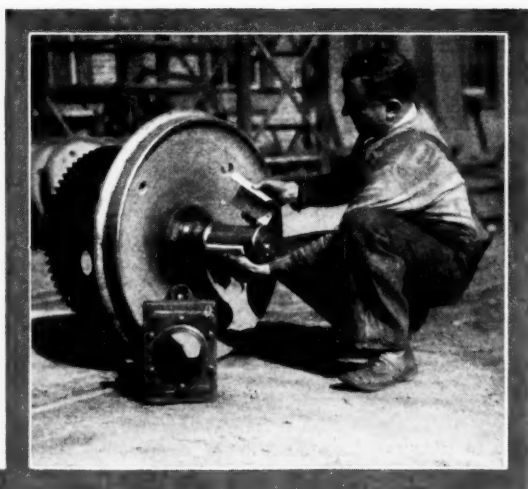
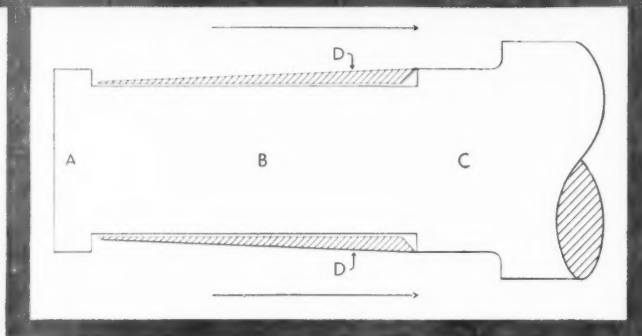


Fig. 6 — Above — Showing the template referred to in Fig. 5 being placed on the journal.

Fig. 7 — Right — Sectional detail of a journal with the template in place. A is the button of the axle, B is the journal, C is the dust guard seat and D the template.



of the latter. Practically speaking, this means its ability to withstand the squeezing out effects of pressure by virtue of the cohesion between its component molecules.

#### *Space Limitations Important*

Of course, Hersey and Shore treat with pressure as applied to lubricants within a space of definite limitations. Rarely will such conditions hold true in actual operation, for it is practically impossible to build the lubricating system so tight in the average heavy duty machine.

It is reasonable to presume, however, that in oil-tight bearings these conditions of test will be perhaps simulated to a certain extent; in other words, the lubricant will be subjected to mechanical pressure at a rate exceeding its ability to leak or pass from the bearing. Under such conditions their statement that—"the effects of high pressure are presumably similar to those caused by cooling to a low temperature at atmospheric pressure"—will be true in actual operation. In other words, it will mean that the relative fluidity and sluggishness of the oil may be markedly increased.

This should promote effective lubrication unless it occurs to an extreme, for the existing oil film will be compressed and rendered more

capable of preventing metal-to-metal contact. But, of course, lack of adequate fluidity must not result, for this might mean that certain parts of the bearing would be receiving practically no oil. Especially would this be true in self-contained circulating lubricating systems.

On most machinery, however, which will be subject to heavy bearing or gear tooth pressures, the lubricating film will have some place to go. In other words, whereas high mechanical pressure may be involved, the lubricant will still be exposed to atmospheric pressure at the ends of bearings or sides of gear teeth.

In consequence, the extent to which it will continuously maintain a lubricating film of adequate thickness will depend upon its ability to resist being squeezed out, as already stated.

#### TEMPERATURE

The influence which temperature will have upon a lubrication recommendation will depend upon the extent to which the operating temperatures may vary. As a general rule, this factor must be considered in deciding upon the manner of preparation of a grease or the melting point of any such product, or the viscosity of an oil, wherever conditions may be deemed to be in any way abnormal.



High temperature operation is worthy of special consideration. High temperature conditions will usually impose a greater duty upon a lubricant than any other phase of operation. In connection with this matter of temperature, it must be remembered that the inherent possibility of development of solid friction will always be present. Solid friction between any two surfaces in motion with respect to one another implies the presence of heat, which is invariably developed by the occurrence of friction.

It is the function of lubrication to eliminate solid or metallic friction, supplementing it with fluid friction, which will normally be of far less intensity.

Where high operating temperatures may prevail the proper viscosity or body of a lubricant must be given all the more careful attention, for viscosity will vary inversely with temperature. In other words, the higher the operating temperature the greater will be the tendency for the body or viscosity of the lubricant to be reduced. If the original viscosity is not sufficiently high to allow for this reduction, the increased fluidity may lead to impairment of the lubricating film to such an extent as to actually cause metal-to-metal contact.

This will be especially apt to occur under comparatively high pressure. It is for this reason that the viscosity-temperature conversion chart should be studied in connection with the formulation of a lubrication recommendation for high temperature operation. By the use of such a chart one can readily determine the operating viscosity of any lubricating oil at the prevailing temperature of operation, knowing the viscosity at some two points such as 100 degrees and 210 degrees Fahr., according to the prevailing marketing specifications. Normally lubricating oils of a viscosity up to approximately 800 seconds Saybolt at 100 degrees Fahr., are specified at this particular temperature. The viscosity of heavier lubricants, however, is usually stated at 210 degrees Fahr.

While the use of an oil of sufficient viscosity to meet the operating conditions will, of course, result in more effective lubrication, it will also prove of decided value in reducing the amount of power or energy required to move the working elements. In addition, any tendency towards the development of abnormal frictional heat will be reduced.

All this will lead to improved lubrication, for it will enable the oil to perform its function more perfectly, maintaining the proper lubricating film under all conditions, by virtue of its viscosity or body.

## The Importance of Viscosity

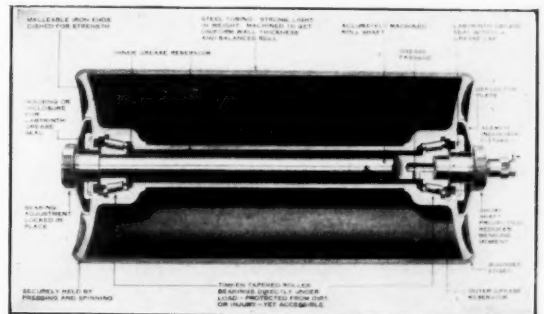
It has already been stated that viscosity varies inversely with the temperature. Under certain conditions this is an asset, for it may permit of one lubricant serving a number of points of varying external temperatures, provided the size of the wearing elements and the pressure exerted are taken into account when the lubricant is originally selected.

On the other hand, the mistake should never be made of regarding the viscosity at say 100 degrees Fahr., as of sole importance, for an oil which might be of adequate viscosity at that temperature might be too light to meet an operating temperature range at say 150 degrees Fahr. As a result, there is a direct tie-up between power consumption, friction and temperature.

## Viscosity Defined

Inasmuch as "operating viscosity" plays so important a part in this matter of high temperature lubrication, a detailed knowledge of viscosity in general will be advisable. Just what is meant by the statement that an oil should have a viscosity of, let us say 500 seconds Saybolt at 100 degrees Fahr., will be vague to many. It is well, therefore, to mention that this means at a uniform temperature of 100 degrees Fahr., it will take 60 c.c. of the oil in question 500 seconds to flow through the orifice of the standard Saybolt viscosimeter.

As a result, viscosity is an indication of the relative fluidity of an oil at the temperature of test. In brief, it is that inherent property by virtue of which the flow of liquids is retarded,



Courtesy of Link-Belt Company  
Fig. 8—Details of the Link-Belt anti-friction belt conveyor idler roll, equipped with Timken tapered roller bearings. By means of a suitable grease seal, housing and deflector lubrication is adequately protected, thereby enabling the proper grade of lubricant to give more satisfactory service.

through the resistance offered by the particles or molecules of a liquid in sliding past each other. It is, therefore, possessed by all oils in varying degrees.

## Low Temperature Operation

It is just as important to study the operating viscosity of an oil where low temperatures are involved as when high temperatures are to be

met. In case of low temperature operation, however, there will be less possibility of metal-to-metal contact between the wearing elements. Under such conditions we must be more concerned with the possibility of developing of abnormal internal friction within the body of the lubricating film itself. This would, of course, lead to increased power consumption. If allowed to become abnormal it might even render the machine inoperative. There would also be the difficulty of delivering such a sluggish lubricant to the moving parts on starting. Should this latter prevail for any length of time, metal-to-metal contact might occur until the temperature of the machine was raised sufficiently to expedite ready flow of the lubricant.

### Melting Point of Grease

Where a grease is involved, the operating temperatures must be given careful consideration in regard to the melting point. There are certain types of such products, of course, which by virtue of their soap content, method

of manufacture and the nature of refinement of the oil used, will have a much lower melting point than others. Cup greases, for example, will show a melting point of around 200 degrees Fahr. Cylinder stock or soda soap products, however, can be compounded to show a melting point of considerably above 300 degrees Fahr.

A cup grease should not be heated above its melting point, or even within the vicinity of same, for any length of time, due to the possibility of evaporation of its normal water content and alteration of the homogeneity. This would be indicated by separation of the oil from the soap.

Installations wherein a fairly high range of temperature may prevail should, therefore, be given very careful study where provisions are made for grease lubrication. Examples of this would be on the bearings of cement mill kiln trunnions, certain types of metal working machinery, some parts of the steel mill and on stoker drive operating mechanisms.

## Means of Lubrication

In determining the proper grade of lubricant for any type of operation, the means provided for its application must be carefully considered and the principles of operation completely understood. There is considerable tendency today to adopt means whereby oil or grease can be automatically delivered to the moving parts. Whether or not an oil will be circulated under pressure, however, depends upon the extent to which the motion of these parts can be employed for delivery of the lubricant.

Circulation pressure lubrication is more strictly confined to bearings, the cylinders of reciprocating engines, and certain types of machine tools, although in the steel industry and certain other plants the same principles have been adapted to gears, where these latter can be tightly housed to prevent loss or contamination of lubricants.

An automatic pressure circulation lubricating system involves some form of a pump. In such systems it is customary to employ comparatively fluid oils. Normally, however, the viscosity will not range above 160-180 seconds Saybolt at 210 degrees Fahr.

There are certain types of mechanical force feed lubricators, on the other hand, which are perfectly capable of pumping very much higher viscosity products.

Lubricators of the automatic pressure variety will, ordinarily, derive their motion from the machinery which they serve. The means of

attachment will depend upon the location and design of the lubricator itself.

Where the oil pump is built directly into the machine, as is commonly done in connection with the automotive engine, it is driven through a gear connection to the main shafting. This principle of operation is applicable to any reciprocating engine. The pumps used are generally of the gear type.

In the mechanical force feed lubricator, however, which is designed for external installation, motion is derived through a link or ratchet connection, to some moving part.

Perhaps the most general usage of the mechanical force feed lubricator is in connection with lubrication of steam cylinders or the cylinders of Diesel engines. It is perfectly practicable, however, to extend this device to virtually any type of industrial machinery where the proper driving connection can be installed.

In view of the importance of the means of lubrication in the formulating of a lubrication recommendation, it will be advisable to study the several more usual types in detail.

### CHAIN AND GEAR DRIVEN PUMPS

The development of automotive engine lubrication has brought the gear pump into decided prominence as a dependable piece of lubricating equipment. It is, in fact, so absolutely automatic as to require no attention

## LUBRICATION

whatsoever from the operator once it has been properly adjusted to develop the oiling pressures required. These, of course, can be varied according to the design of the machine or the season of the year. A word or so in explanation of the operation of such a system will be of interest at this point, viz.:

### The Automotive Type

The typical pressure system of lubrication as applied to the automotive engine provides for pumping of oil from the reservoir or oil sump in the crankcase directly to the main or crankshaft bearings. From here it passes through suitably drilled holes in the crankshaft to the crankpins.

Oil as it passes through these latter is thrown to the cylinder walls to maintain the requisite film of lubricant thereon. The pistons and rings are thereby furnished with adequate lubrication as are also the wrist pins within the pistons.

Such a system of lubrication involves no real splashing of oil in view of the fact that there is no provision for dipping of the connecting rods, although a certain amount of oil will be thrown to the cylinder walls as stated above. All excess oil drains back to the oil sump for subsequent redistribution by the pump.

The full pressure system of lubrication differs from the above only in that the wrist pins are also pressure lubricated, oil being delivered via drilled holes in the connecting rods or through separate tubes attached to these latter.

This oil as it passes from the wrist pins serves to supplement the lubrication of the cylinder walls as provided by the oil thrown from the crank-pins. Drainage throughout the engine is returned to the oil reservoir for redistribution.

### Industrial and Power Plant Machinery Devices

In connection with industrial and power plant machinery, the gear and shaft driven pump may be supplanted by chain and sprocket connections. With such equipment the pumping device may be of either the gear or rotary type. The former is used for example in the vertical reciprocating engine, the rotary pump being in turn employed to deliver oil to the bearings of the machine spindle.

With all equipment of this nature the pump itself must be located below the operating oil level in the base or sump of the machine to

be served. As a result, there must be adequate storage capacity to permit of cooling and settling of the return oil as much as possible; for with any system of this nature continuous circulation of oil is developed.

By virtue of the pressure involved in such circulation, and the volume of oil delivered to the wearing elements, this oil serves as a flushing and cooling medium. It is, therefore, natural to expect that more or less contaminating or non-lubricating matter may be accumulated in the course of circulation. In addition, a certain amount of heat may be taken up from the bearings or gears. All this will depend, however, upon how dust-tight the system is, the speed of operation, the bearing pressures, and the proximity to other production or power generating equipment which may develop dust, or high temperatures.

### CENTRALIZED PRESSURE LUBRICATION

Another interesting phase in connection with pressure lubrication has been the development of a system of automatic lubrication which functions by virtue of a central control, all wearing parts so served being flushed and supplied automatically with oil from a central reservoir. By locating this latter adjacent to the machine to be lubricated and within ready reach of the operator, and equipping it with a suitable plunger which operates the pump, lubrication of all parts connected thereto becomes but a matter of pressing a button, pulling the plunger or turning a wheel whenever

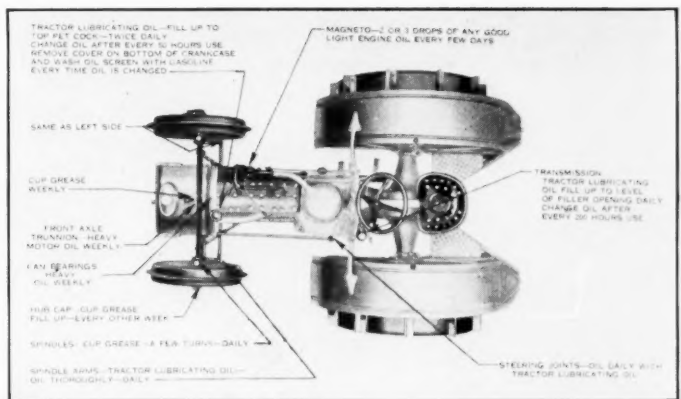


Fig. 9—Top view of a Fordson tractor, showing parts requiring lubrication and the approximate grade of lubricant which should be used on each.

Courtesy of Ford Motor Company

necessary or recommended by the builders, according to the operating conditions involved.

In such a system the amount of oil fed is restricted to as nearly as possible the theoretical lubricating requirements of the respective

bearings. As a result, it may rightly be classified as a "fresh oil" system.

The fact that certain bearings will vary from others in regard to their oil requirements renders it necessary to provide for some arrangement for regulation or control of oil flow. Practically this amounts to a metering of the oil in terms of drops. It can be brought about either by proper individual construction of the drip plugs, which on such equipment are also known as control outlets; by use of a control device located at the base of the pump, or by the installation of suitable adjusting manifolds at salient points in the system.

Properly installed such systems are claimed to be relatively fool-proof, exceedingly simple to operate, and an insurance that clean oil will be delivered to the respective bearings. It is essential, however, that all parts be of rigid construction and capable of withstanding jars, shocks, and temperature fluctuations, for while piping, etc., is guarded wherever possible, it is relatively impossible to absolutely protect all parts from the chance of contact with external materials.

### THE MECHANICAL FORCE FEED LUBRICATOR

With the mechanical force feed oiler, not only is one-time lubrication involved, but furthermore, oil is delivered in as nearly as possible the requisite amount to meet the bearing or cylinder requirements. With due care when installing and proper adjustment of the rate of oil feed, such lubricators are dependable and decidedly economical.

There is a further advantage in that by

proportional speed. In other words, the higher the speed of operation, the more oil will be delivered. The pumping capacity and rate of oil flow is therefore variable. As a result, such a lubricator will automatically start or stop with the machine or engine to which it is attached.

Equipment of this nature is very extensively used for the application of steam cylinder, air compressor or refrigerating compressor oils, viz.: For the lubrication of cylinder, piston and valve wearing surfaces, where reciprocating motion is involved, and where it is practicable to drive the lubricator by direct connection from the crosshead or some other external moving part. This can be brought about by a link mechanism as is generally customary in the case of steam cylinders; or through an eccentric located on some rotating element, such as the cam shaft of a vertical oil engine.

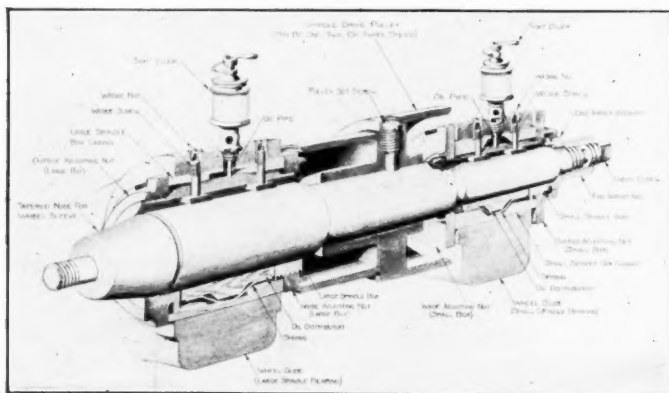
Such lubricators are also widely used for bearing lubrication on metal presses, machine tools, rubber and steel mill machinery. On such equipment rotary driving is often customary, through belt connection from the machine itself or by use of an electric motor and speed reduction mechanism.

### Nature of Construction

The typical mechanical force feed oiler consists of a bowl or reservoir of varying capacity ranging normally from one pint to two gallons. Within this reservoir, or attached thereto, is the pumping element or block. To this latter is attached the operating ratchet, clutch or belt connection.

The design of pump employed will depend upon the type of lubricator. In general, it will involve a piston or plunger. According to the service involved, quite a number of such pumping units can be embodied in the one lubricator. Furthermore, this latter can be divided into two or more parts so that more than one grade of oil can be delivered by the same lubricator. Where this latter prevails, however, care must be observed in filling in order to make sure that the right oil is always put in the proper compartment.

Actual operation of the pumping element is brought about by an eccentric or cam located usually within the reservoir. It receives its motion through the exterior operating mechanism such as the ratchet. It is practicable to arrange the design so that each pumping unit will operate independently, and capable of individual regulation. In



*Courtesy of Norton Company*

Fig. 10—Details of a grinding machine spindle, showing the bearing construction, oil distributors and sight feed oilers. This is for high speed operation where every care must be given to consideration of the operating conditions before determining the proper grade of oil to be used.

virtue of the fact that such lubricators can be readily driven by the machinery which they serve, they can be made to function only when the latter is in operation, and then only at a

operating mechanism such as the ratchet. It is practicable to arrange the design so that each pumping unit will operate independently, and capable of individual regulation. In



order that the extent of lubrication or rate of pumping can be observed, oil is delivered from the pump unit through a suitable gauge glass or sight feed device. The purpose of locating this latter in the discharge line is, of course, to enable observation of oil flow, after the lubricator has functioned.

## PRESSURE APPLICATION OF GEAR LUBRICANTS

It will also be interesting to note that automatic means for pressure application of gear lubricants has been developed for the collective lubrication of reduction gears.

In the course of lubrication of gearing, especially on many types of industrial machinery, the matter of assuring positive, cleanly and economical application of lubricants to the gear teeth may become a problem. This will be particularly true where gears are exposed, or but partly enclosed, for in such installations the tendency of lubricants to be thrown off by the action of centrifugal force must be guarded against.

This will, however, depend upon the viscosity and adhesive characteristics of any lubricant. Where application or re-lubrication is to be done by hand, these characteristics must be given very careful consideration in deciding on the proper grade of lubricant, otherwise not only may the gear teeth suffer, but also a sloppy condition may prevail, due to dripping or throwing off of the lubricant.

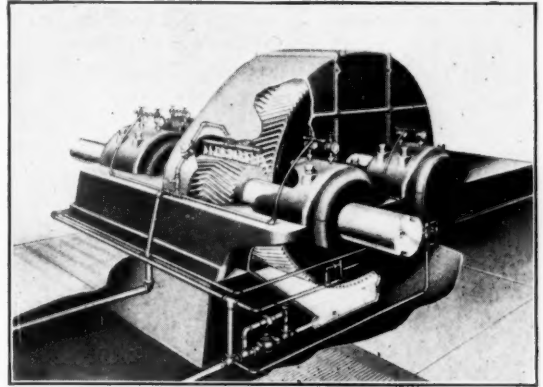
For this reason, gears are housed or guarded wherever practicable. Furthermore, automatic lubrication has been extensively studied by machinery builders, by resorting to means of delivering the gear lubricant to the teeth as they pass into mesh, in more nearly the right amount to maintain lubrication.

## RING AND CHAIN OILERS

Lubrication of bearings by ring or chain oilers involves continual delivery of oil to the wearing surfaces by means of a ring or chain suspended from the shaft, and free to rotate therewith, the lower part dipping in a bath of oil which is carried in a suitable reservoir in the lower part of the bearing shell.

In order to insure effective lubrication by such mediums the reservoir must be of adequate capacity to give the oil ample opportunity to rest, thereby making possible not only the settling out of sediment and other foreign matter, but also cooling to the requisite degree. As a rule the only way in which the oil in such a system is kept at the proper temperature is by radiation of heat from the exterior surfaces of the reservoir or lower part of the bearing.

Oil which is carried to the top of a ring or chain oiled bearing must, of course, be taken care of and returned to the reservoir as rapidly as it is delivered by the ring. If this is not possible, oil will tend to accumulate in the



*Courtesy of S. F. Bowser and Co., Inc.*

Fig. 11—Gear lubrication can be effectively protected by automatic delivery of oil to all parts of the gear teeth. Here is shown a circulating lubricating system, applied to a set of herringbone gears, oil being delivered to the point of mesh. Flood lubrication in this manner results in more effective reduction in temperature and prevention of wear from abrasive foreign matter.

upper part of the housing to ultimately be forced out from the ends of the bearings.

The same condition may arise if the oil is carried too high in the well, or if the ring rotates at too high a speed. This will cause a splashing and churning of the oil.

## COLLAR OILERS

The principle of the collar oiler is much the same as that of the ring oiler, i.e., it involves the circulation of oil from a suitable reservoir in the base of the bearing. This is brought about by means of a collar considerably larger in diameter than the shaft, which is fastened to the latter at approximately the center of the bearing.

Such lubrication may be regarded as of more essentially the flood variety. Furthermore, it will, as a rule, be more positive than in the average ring oiler, by virtue of the fact that as soon as the shaft begins to rotate the collar being fast thereto will likewise be set in motion to carry oil immediately to the top of the bearing. As a result the requisite film of lubricant will be formed more rapidly on starting and maintained more effectively, especially under slower speed conditions.

An added advantage which is claimed for the collar type bearing oiler is that there is relatively no possibility of cessation of lubrication as long as the oil level in the bearing reservoir is maintained at a high enough level to insure adequate dipping of the collar.



### DRIP LUBRICATION

The sight feed oil cup and wick oiler will maintain effective lubrication of many types of marine and stationary bearings. Sight feed oilers involve individual lubrication of the respective bearings as a rule, with a consequent need of individual attention as to filling and adjustment. They are, however, advantageous, in that they normally permit of observation of the oil content from the operating floor.

The wick feed oiler, in turn, can be of either the individual or manifold type. Each is economical from a labor saving point of view, though they may perhaps involve oil waste if improperly designed, adjusted or controlled. The manifold type can be built on very much the same lines as the wick oiler employed on certain classes of marine steam engines. Wick oiling on the whole is decidedly advantageous provided that the wicking is of proper texture and in good condition, for the wick will serve as an effective strainer to insure delivery of clean oil to the bearings. Periodic cleaning of wicks, of course, is advisable if the above is to be continuously maintained.

There will always be certain bearings, however, which will not require such positive means of lubrication. Usually they can be hand-oiled two or three times a day. To facilitate this the spring-cover type of oil cup is frequently installed.

### PRESSURE GREASE LUBRICATORS

Where heavier lubricants may be necessary for individual bearing lubrication, the use of grease will often be advisable. Mechanical or hand pressure grease lubricators will handle such lubricants admirably.

The pressure grease lubricator may be either of the hand or power type. For the use of the individual machine operator, the former is perhaps the most suitable device. In large installations, however, where considerable equipment may be involved, the power lubricator will often be an adjunct as a time and labor saver.

Another noteworthy piece of equipment is the constant pressure grease lubricator for use in connection with the pressure grease gun. In effect it has been designed to eliminate the necessity for frequent re-lubrication. It is, in

fact, as nearly positive and automatic as practicable over the length of time that its charge of grease will last.

### GREASE CUP LUBRICATION

In view of the necessity for a means of lubrication that will function relatively automati-



*Courtesy of Fairbanks, Morse and Company*

Fig. 12—Showing the conditions of operation to which electric motors may sometimes be subjected, and which must be considered in making a lubrication recommendation, to insure adequate protection of the bearings against entry of contaminating or abrasive foreign matter.

cally and be capable of withstanding hard knocks, the grease cup is also extensively used on certain types of bearings. In some cases such bearings are located in dangerous and inaccessible positions, where regular oiling, or the filling of oil cups, etc., would be comparatively difficult or even impossible without complete shut-down.

Grease lubrication by means of the spring regulated compression cup or the relatively automatic pin type of cup is in such cases regarded by many engineers as an effective means of keeping such bearings operating with a minimum of care and danger to operators.